INTERNATIONAL HARMONIZED RESEARCH ACTIVITIES
REPORT OF WORKING GROUP ON INTELLIGENT TRANSPORT SYSTEMS (ITS)

Y. Ian Noy and Peter C. Burns
Transport Canada
Canada

ABSTRACT

The International Harmonized Research Activities Working Group on Intelligent Transport Systems was established to coordinate government research aimed at developing harmonized procedures for the evaluation of safety of in-vehicle information, control and communication systems with respect to human performance and behaviour. This report describes some of the activities completed in recent years and recommendations are provided for the future success of the WG. It is anticipated that increased public and government concerns about ITS safety in the future will stimulate increased interest, expectation and funding of harmonized research.

BACKGROUND

The International Harmonized Research Activities Working Group on Intelligent Transport Systems was established to develop procedures (including methods and criteria) for the evaluation of safety of in-vehicle information, control and communication systems with respect to human performance and behaviour.

The impetus behind this WG reflects the need for governments to understand and minimize the potentially adverse consequences of ITS technologies. Harmonized research in ITS is of special importance for three reasons, 1) it represents a significant opportunity to influence active safety (also known as primary safety or crash avoidance) through effective collision avoidance intervention, 2) it addresses a global need to more clearly define the role of government with respect to ITS safety, 3) it represents an area essentially unregulated at the present time; consequently, there is a greater likelihood of achieving harmonized safety policies than might otherwise be the case.

The WG was formed in 1996, following the establishment of the IHRA program at the ESV conference in Melbourne. It was given an initial mandate of 5 years, which was extended indefinitely at the 17th ESV conference in Amsterdam with periodic review and refocus on specific areas of interest as needed. This report summarizes the activities during this period, and offers recommendations for continued cooperation in this area.

INTRODUCTION

The International Harmonized Research Activities is an inter-governmental initiative that aims to facilitate greater harmony of vehicle safety policies through multi-national collaboration in research. IHRA is organized under the auspices of Enhanced Safety of Vehicles (ESV) representing the U.S., UK, Canada, the Netherlands, Germany, Australia, Sweden, Japan, France, Italy, Hungary, and Poland. In addition, the European Commission (EC) and the European Enhanced Vehicle-safety Committee (EEVC) are represented. The Working Group on ITS is one of five working groups addressing high-priority research needs.

Definition

In-vehicle Intelligent Transport Systems (ITS) are on-board systems that utilize information that is received from direct sensing (such as radar) and/or telecommunications via the road infrastructure or other source.

It is important to emphasize that certain ITS applications use advanced technologies to provide in-vehicle support for reducing the number of crashes and attendant injuries and deaths. Other ITS applications provide in-vehicle information for purposes other than improved safety. Whatever the primary function, both types of ITS applications can have important unintentional influences on safety (positive and negative) and need to be understood by governments when considering policy alternatives.

The advent of ITS is revolutionizing motor vehicle transportation. Not only is the nature of driving changing radically, but it will likely to be in a continuing state of flux, at least in the foreseeable

future, as technologies continue to evolve. Governments throughout the world are actively promoting the deployment of ITS technologies to achieve greater safety and mobility benefits.

It is important to ensure that new systems and technologies are guided by human factors principles and data so that they do not lead to driver behaviours and responses that were unanticipated by systems designers. In aviation, for example, increased pilot assistance and automation has unwittingly reduced situational awareness and produced out-of-the-loop performance problems (i.e., increased errors and response latency). The risks associated with increased automation (e.g., driver distraction, behavioural adaptation, loss of skill, and negative transfer) are not well understood and cannot be reliably predicted at present.

For vehicles that are not fully automated, the impact of technological change on safety will depend on its implementation and, in particular, on the extent to which the system supports drivers' needs and is compatible with human capabilities and limitations. Not all on-board information, control and communication systems will have the same degree of impact on human-machine interactions. Those that have a critical impact will require more careful human factors analysis. It should be mentioned that the term “human-machine interactions” refers to the broad range of behaviours associated with the driving task, including strategic, tactical and operational control of the vehicle and its sub-systems. The primary human factors issues concern central human processes such as driver attention, situation awareness and cognition. Secondary issues concern peripheral processes (e.g., legibility) that are affected by the physical design of the human-machine interface.

Within the broad area of ITS safety, the WG has identified human-machine interaction as the principal focus of interest. The WG is concerned with developing methods for the final test and evaluation of systems prior to their introduction into the market. It is recognized that during their development, systems undergo design iterations that involve the collection and analysis of relevant human performance and other data. These formative evaluations are conducted at various stages of system development to check system performance against corporate objectives and specifications. They are primarily within the control and serve the interests of industry and, as such, are beyond the scope of this WG. While formative evaluations are important and can contribute to overall system safety, safety assurance relies on evaluations of systems that are ready for implementation in the real world.

Participation

The following countries have participated in the ITS WG: Australia, Canada, France, Germany, The Netherlands, Japan, Poland, Sweden, U.K., and the U.S. While most WG members represent national governments some members come from the automotive industry. In certain cases, notably France, Germany and Japan, the national representatives come from industry or government research organizations and participate on behalf of the relevant government agencies.

Member list

A list of current WG members is provided in Appendix A.

List of Meetings

The WG meets normally semi-annually. As at time of writing, seven meetings of the WG have been held as follows:

1. April 1997, Rotterdam, The Netherlands
2. October 1997, Berlin, Germany
3. April 1998, London, England
4. June 1998, Windsor, Canada
5. April 1999, Washington, DC
6. October 1999, Stockholm, Sweden
7. April 2000, Lyon, France
8. October 2000, Ottawa, Canada
9. June 2001, Amsterdam, The Netherlands
10. November 2001, Cologne, Germany
11. June 2002, Tällberg, Sweden
12. February 20-21, 2003, Lyon, France
13. May 23, 2003, Nagoya, Japan

The minutes of these meetings are posted with other working group information on the IHRA web site (www-ihra.nhtsa.dot.gov).

SUMMARY OF ACTIVITIES

A number of initiatives have been completed, including the formulation of an overall framework for ITS safety assurance and the role of the ITS WG within this framework, a series of workshops on the

safety test and evaluation of ITS, the definition of priority research problem statements and research progress. These initiatives were described in a report published in the proceedings of the 17th ESV conference in Amsterdam (Noy, 2001). The present report describes some of the significant activities and progress since this last report.

Surveys

The WG conducted a survey of relevant research either on-going or that has been completed within the last 5 years. The definition of relevant work includes any study or demonstration that contained test and evaluation elements, or work that specifically set out to develop or validate protocols, procedures or techniques for the evaluation of safety. Some 50 projects were identified and entered into a database. It was noted that there are relevant research not currently captured in the database, some representing collaborative projects among European countries. WG members will continue to provide input on an on-going basis to ensure that the database is as comprehensive as possible. The database is currently being updated with results from the latest survey.

WP.29 Liaison

The ITS-WG has also served as an advisory on ITS safety issues for the WP.29 World Forum for Harmonization of Vehicle Regulations. A liaison was started with the WP.29 informal group on ITS following a 2001 presentation from the IHRA about the state-of-the-art and safety issues in ITS. With this liaison, IHRA research and expertise on ITS should help to support the future regulatory development work of WP.29.

Project summaries

The IHRA-ITS Workshop on ITS Safety Test & Evaluation, Washington, DC, 1999 generated 16 projects that can advance ITS safety test and evaluation methodology through collaborative international research. The WG selected a set of these projects as representing priority areas for research. Project leaders were identified to coordinate activities within each project domain. The 7 active priority projects and recent progress on these projects are outlined below.

1: Development Of A Harmonized Safety Evaluation Methodology Framework (Worldwide)

The objective of this project is to develop a Harmonized Safety Evaluation Methodology Framework for in-vehicle information, control, and communication systems with respect to human performance and behaviour. An inventory of possible methodologies for road safety evaluation of in-vehicle systems, including a variety of experimental and observational approaches, has been developed and is currently being evaluated for relevance, validity and suitability.

A considerable amount of progress has been made in this area as a result of this working group. This includes a joint German-Swedish-Japanese project initiated under the umbrella of the IHRA ITS-WG to develop a harmonized evaluation framework. A paper describing this work is presented at this conference (Gelau et al, 2003, 18th ESV, Nagoya). The overall objective of this study was to contribute to the definition and validation of a "battery of tools" which enables a prediction and an assessment of changes in driver workload due to the use of in-vehicle information systems (IVIS) while driving. To achieve these goals experimental validation studies (on-road and in the simulator) were performed in Sweden, Germany and Japan. As a common element these studies focused on the secondary task methodology as an approach to the study of driver workload (see Project 6). Results of this collaboration emphasised how relatively large task demands can be expected even from simple traffic situations.

The extension of the European project HASTE to include international participation was also initiated through this working group. The aim of HASTE (Human Machine Interface And the Safety of Traffic in Europe) is to develop methodologies and guidelines for the assessment of in-vehicle information systems (IVIS), i.e. to formulate pass/fail criteria for IVIS. A major technical and scientific objective of HASTE is the identification and exploration of the relationship between traffic scenario, driver and IVIS. This relationship will be investigated by studying behavioural, vehicle, and psycho-physiological, and self-report measures.

A network of excellence and integrated projects related to the development of a harmonized safety evaluation methodology are also being proposed for

the European 6th Framework research programme. This WG will have input into this work.

2: Driver Understanding And Expectation Of ITS Systems: Identification And Measurement Of The Effects Of False Expectation Of Driver Performance

The purpose of this project is to identify factors that affect a driver's understanding of ITS system functional characteristics and determine how they develop performance expectations for these systems. In particular, the main objective is to assess the safety consequences of mismatches between driver expectation and system performance.

Drivers may have a variety of ITS applications available to them, each having different operating characteristics. The picture is further complicated by the fact that for a particular type of ITS, such as ACC, system performance characteristics may vary from one vehicle/system to another. How well the driver understands the ITS application and the expectation he or she has for its performance can directly impact the safety of its use.

Although no projects are planned to expressly investigate system failures and user understanding, these issues are being addressed wherever possible within the other ITS-WG research projects. For example, a study was conducted by Transport Canada to assess the impact of Adaptive Cruise Control (ACC) on driver behaviour (Rudin-Brown, Parker and Noy, 2003). Part of this test-track study investigated driver response to system failures (failure to sense lead vehicle). On average, it took drivers 23s to detect and respond to a failure of the ACC system. These results emphasize how vital system reliability is to the safety of driver assistance systems. The study concluded that clearer feedback must be used to indicate when ACC systems do not detect a target vehicle.

Efforts will continue to ensure that these issues concerning driver understanding of ITS are always considered within future IHRA ITS-WG research projects.

3 Human Factors Principles Checklist For In-Vehicle Systems

The purpose of this project is to develop a checklist based on human factors principles to be used in the safety evaluation of in-vehicle systems.

Bilateral co-operations for the development of evaluation methods are in progress. A further catalyst has been the European Commission's recommendations on HMI and the need to address issues of testing, evaluation and compliance with these HMI principles. TRL in the UK have developed a checklist to assess the suitability of in-vehicle information systems for use while driving. Work is underway in Sweden at VTI to further develop this UK checklist so that it will specifically apply to the European Statement of Principles on HMI.

4: Normative Data On Naturalistic Driving Behaviour

The purpose of this project is to characterize driving behaviour in realistic situations by developing a driving performance database which comprises data on normal driving behaviour, in-vehicle ITS system usage, safety critical events, and crash data.

Naturalistic driving means unsupervised driving on public roads. The vehicle used can be the driver's personal vehicle or it can be one provided by the project team. In most cases, the vehicle will include instrumentation for collecting data on driver and vehicle performance. Similarly, normative driving is taken to mean driving that is done without the assistance of any experimental device. Normative data is often gathered for the purpose of eventual comparison with similar data when the driver does have assistance from some type of experimental in-vehicle equipment. Hence, the data that is collected may be focused on specific situations and conditions that are related to the purpose and performance of experimental equipment.

The U.S. have taken a very active lead on this project. Several projects providing naturalistic driving data have been completed. These include field operational tests of an Adaptive Cruise Control system on passenger vehicles and also on heavy trucks, a Collision Warning system on passenger vehicles and also on heavy trucks, and a Rollover Stability Advisory system on heavy trucks.

Most recently, a naturalistic driving project is being conducted to provide insight into how drivers avoid collisions. In this project, a data acquisition system will be added to the vehicles of volunteer drivers. Data will be continuously collected as the drivers go about their daily routines. The data will be analyzed to develop a better understanding of how drivers

react to impending crashes and near-crashes. There will be 100 vehicles in the fleet of these vehicles. The first 20 have been outfitted with the data acquisition system and data collection has begun. The project will run for one year. At the end of that time a plan will be developed for a similar larger scale naturalistic driving project.

http://www-nrd.nhtsa.dot.gov/pdf/nrd-12/100carphase1report.pdf

5: Simulator Reference Test Scenarios

The goal of this project is to develop a catalogue of driving scenarios for use in driving simulator research. The set of scenarios should encompass the breadth of driving possibilities from uneventful everyday situations to safety critical situations.

Simulator reference test scenario 'tiles' are to be defined. The idea being that most nations have their own highway idiosyncrasies. However, with predefined test scenarios in the form of tiles or templates, the appropriate reference test scenario tile for the respective simulator and local highway characteristics can be adopted. Therefore, with these tiles, one can more readily compare the results from different simulators with a higher degree of comparative validity. There are many benefits from the usage of internationally agreed upon simulator reference test scenario-tiles. Towards this goal, an international workshop is planned to help develop a catalogue of driving scenarios. The workshop is scheduled for October 2003 and is being held in conjunction with the Driving Simulator Conference - North America (DSC-NA) in Dearborn, Michigan.

6: Improved Secondary Task Methodology For Evaluating Safety Effects Of Driver Workload

The goal of this project is to develop a useful secondary task methodology to calibrate workload effects of combining in-vehicle and out-of-vehicle information. Although within the scope of Project 1, Development Of A Harmonized Safety Evaluation Methodology Framework, this topic was considered to be important enough to constitute a project in itself. The joint German-Swedish-Japanese research described under Project 1 also focused on the secondary task methodology as an approach to the study of driver workload.

Work on secondary task methods has been conducted in the HASTE project, also described among the activities relevant to Project 1. As part of HASTE, the Institute for Transport Studies at Leeds University has developed a surrogate in-vehicle information system task. This will be used as a common reference task by all research partners in the consortium and will help to compare measures and results.

Most recently, Transport Canada has created a speech based secondary task to measure the workload of speech-user interfaces in vehicles. Speech-user interfaces are promoted by some as the panacea for driver distraction from ITS. However, the safety of speech remains to be proven. This work will examine the impact of in-vehicle speech-based email messages as a function of speech presentation type (synthetic speech and human speech), message complexity (easy vs difficult) and driving environment complexity (easy /difficult). The secondary task is email messages based on everyday, typical email topics such as scheduling meeting, arranging travel plans etc. The complexity manipulation is based on the verbal reasoning work of Hitch & Baddeley (1976) who demonstrated that manipulations of active/passive sentence construction and affirmative/negative responses had an impact on speed and accuracy of responses.

JARI are currently conducting a review to document all of the secondary tasks methods that have been used to measure driver workload. The WG will provide input for this review.

7: Harmonization And Validation Of Surrogate Safety Measures

The goal of this project is the harmonization and validation of surrogate safety measures.

Surrogate safety measures are measures that can be used to estimate numbers of crashes and resulting injuries and deaths. Many projects, probably most, do not have access to large databases of events that provide a basis for directly estimating the number of crashes and the impact of vehicle-based systems on the likelihood of crashes. Thus, surrogate measures are measures that can help estimate numbers of crashes and resulting injuries and deaths. Surrogate measures are usually related to specific types of problem (for example, surrogate measures for rear-end crashes are probably different than surrogate measures for road departure crashes).

The U.S. lead on this program has developed surrogate measures for some types of situation and

crash. Others are currently being developed. One such new methodology is called the crash prevention boundary (NHTSA). This methodology separates the space of driver performance into a region of performance that avoids a crash and a region of performance that results in a crash. This methodology provides new insights into the safety impact of technologies. The methodology is described in more detail in papers at several recent technical conferences.

CONCLUSIONS

Research in this area is relatively new in comparison with passive safety, the latter having had the benefit of considerable R&D investments over many years. The activities of the WG, including the development of a research framework and initiation of priority projects, surveys and workshops have proven to be of value. A further benefit is the informal sharing of information among WG members about activities in different countries. This is very important since it is currently the only forum with the express purpose of coordinating government research in this area. Moreover, interest in this WG seems to be growing, owing largely to a growing awareness of the need for ITS safety policy. Thus, the IHRA-ITS WG has the potential to play a major role in ITS safety.

WG members believe that inter-government collaboration in ITS safety research is an important activity - one that serves the interests of both government and industry in meeting the challenges of safety in a global economy. ITS-equipped vehicles are only just being introduced into the market. As technologies evolve, there will be a constant need for governments to monitor the safety of these systems and to adapt policies to respond to public expectations.

The WG anticipates a need for increased involvement by participating countries, particularly at technical levels. For example, there is a need for technical reviews of national research projects in order to assess, on a global level, research findings and implications, and to identify new research directions. This represents a turning point for the WG in that it implies a much greater involvement in detailed reviews and technical analyses than has been possible to date.

RECOMMENDATIONS FOR FUTURE WG ACTIVITIES

For the future success of the ITS WG, it is recommended that the group:

- Continue to provide technical assistance for the informal ITS group in WP.29 and other groups.
- Continue with the valuable international research collaborations on ITS safety evaluation and encourage more of this work.
- Update the ITS safety evaluation research database on an on-going basis.
- Continue with the successful role of the WG as a forum for sharing research information on ITS and
- Expand this exchange of information with presentations by invited experts at WG meetings and other forums.

APPENDIX A: MEMBERS AND RECENT PARTICIPANTS OF IHRA-ITS WORKING GROUP

Ian Noy & Peter Burns, Transport Canada, Canada

B. Friedel & Christhard Gelau, BASt, Germany

Christopher Patten, SNRA, Sweden

Jan Busstra, Ministry of Transport, The Netherlands

August Burgett, NHTSA, United States

Kaneo Hiramatsu, JARI, Japan

Ray Kiefer, General Motors, United States

Annie Pauzié, INRETS, France

Geoff Harvey, Department for Transport, UK

Daniel Augello, Renault, France

Kenji, Niiya, Toyota, Japan

Valerie Moutal, DG Info Soc, EC